

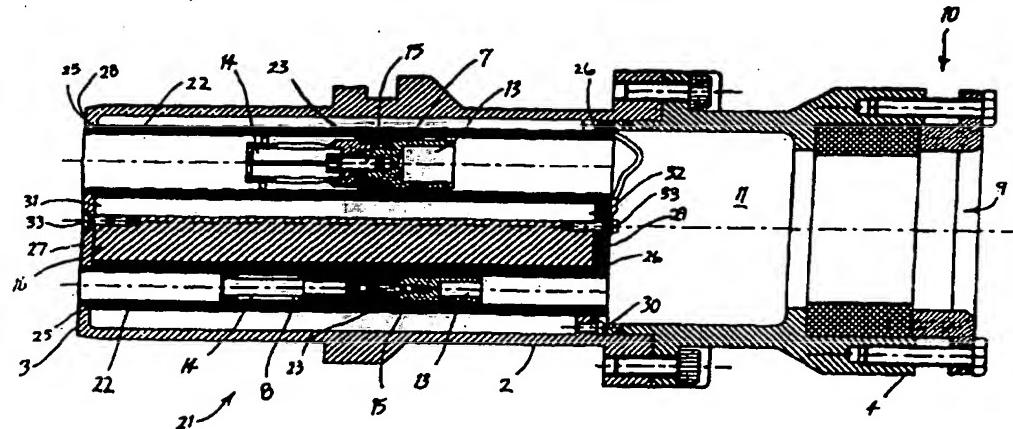
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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(73) Published			With international search report.

(54) Title: ELECTRICAL PLUG



(57) Abstract

An electrical plug (21) includes six equally angularly spaced axially extending tubular insulators (22) which have a central internal annular ridge (23) against which a thimble (13) and a socket (14) are collectively secured by the operation of bolt (15). A phase barrier (16) is a structural member being engaged at opposed ends (31, 32) by respective plates (27, 29). The plates are forced toward each other and into clamping engagement with insulators (22) by the action of bolts (33) which are threadedly engaged within complimentary bores in barrier (16).

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**TITLE: ELECTRICAL PLUG****TECHNICAL FIELD**

The present invention relates to an electrical plug.

The invention has been primarily developed for medium to high voltage and/or  
5 medium to high current multi-core power supply cables such as those used in the  
underground mining industry and will be described hereinafter with reference to that  
application. However, it will be appreciated that the invention is not limited to that  
particular field of use.

Known electrical plugs for power supply cables used in underground mines have  
10 generally included an axially extending cylindrical body which is configured at one  
end for insertion into a complimentary receptacle having a number of connector pins.  
The other end of the body is configured to receive a multi-core cable. Within the body  
the ends of the cable cores are electrically connected to respective internal contacts  
which, in turn, selectively electrically engage with the connector pins within the  
15 receptacle.

As it is necessary to insulate the ends of the various cores in the multi-core cable  
from each other the body generally includes a one piece moulded insulator which  
surrounds the internal contacts and allows them to contact only a respective connector  
pin. An example of a known electrical plug is illustrated in Figures 1 and 2 and will  
20 be described below in more detail.

The known plugs are particularly disadvantageous as they are heavy and the  
insulator is prone to damage and is difficult to replace without at the same time  
replacing all the internals of the body. In a mine environment where operating

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conditions are harsh the known plugs are particularly undesirable as they are expensive to maintain in safe working condition.

#### DISCLOSURE OF THE INVENTION

It is an object of the present invention, at least in the preferred embodiment, to  
5 overcome or substantially ameliorate this disadvantage of the prior art.

According to a first aspect of the invention there is provided an electrical plug including:

a body extending between a first end and a second end which are respectively  
10 configured for insertion into a corresponding receptacle and receiving an electrical  
cable having one or more cores; and

15 at least one tubular insulator, the or each insulator having a connector for  
receiving at one end the respective ends of the one or more cores and at the other end a  
respective connector pin within the receptacle to allow releasable electrical connection  
between the cores and the connector pins.

20 Preferably, the plug includes:

a first and a second plate respectively located at or adjacent the first end of the  
body and intermediate the first and second ends of the body, both plates having a  
plurality of apertures which align with respective ones of said insulators; and  
retention means extending between said plates for captively retaining the  
insulators therebetween.

25 Preferably also, the retention means includes a member extending through the  
cavity. More preferably, the member is a phase barrier. Even more preferably, the  
member is tensioned.

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In a preferred form, the or each tubular insulator is cylindrical. Alternatively, the or each insulator has a square cross section.

Preferably, in circumstances where a plurality of insulators are used they are equally angularly spaced within the cavity.

5 Preferably also, the or each insulator is surrounded by a respective additional tubular insulator. More preferably, the or each insulator is separated from the additional insulator by an air gap.

In a preferred form the connectors are disposed wholly within the respective tubular insulators.

10 According to another aspect of the invention there is provided an electrical plug including:

a body extending between a first end and a second end which are respectively configured for engagement with a complementary electrical plug and receiving an electrical cable having one or more cores;

15 one or more connectors for receiving at respective first ends the one or more cores and at respective second ends a connector formation associated with the complementary plug to allow releasable electrical connection between the cores and the connector formations; and

one or more insulating sheaths extending about respective ones of the one or  
20 more connectors for electrically isolating the connectors from each other.

Preferably, the connectors are metallic and the sheaths are plastics sleeves. In other embodiments the sheaths are defined by a layer of ceramic material which is deposited on the outside of the connector.

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Preferably also, the body includes a solid conductive core. More preferably, this core is generally cylindrical and includes a plurality of spaced apart parallel axially extending passages through which the respective insulating sheaths extend. More preferably, the core is earthed. Even more preferably, the core is metallic.

5 **BRIEF DESCRIPTION OF THE DRAWINGS**

Some preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

- Figure 1 is an end view of a known electrical plug;
- Figure 2 is a cross section taken along line 2-2 of Figure 1;
- 10 Figure 3 is an end view of an electrical plug according to the invention;
- Figure 4 is a cross section taken along line 4-4 of Figure 3;
- Figure 5 is an end view of an alternative electrical plug according to the invention;
- 15 Figure 6 is a cross section taken along line 6-6 of Figure 5;
- Figure 7 is an exploded cross sectional view of the plug of Figure 6;
- Figure 8 is an end view of another electrical plug according to the invention;
- Figure 9 is a cross section taken along line 9-9 of Figure 8; and
- Figure 10 is a cross sectional view of an adaptor for the plug of Figure 8;
- 20 Figure 11 is an exploded cross sectional view of the plug of Figure 9.

**MODES FOR CARRYING OUT THE INVENTION**

Reference is made to the prior art electrical plug 1 of Figures 1 and 2. The plug includes a generally cylindrical body 2 extending between a first end 3 and a second end 4 which are configured respectively for insertion into a corresponding receptacle

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(not shown) and receiving a multi-core electrical cable (not shown). As is well known to those in the art, multi-core cables generally include three equally spaced apart medium or high voltage mains conductors and one or more pilot cores for carrying communication signals. Body 2 includes a single piece moulded interior insulator 5 which extends from end 3 and terminates at end 6, which lies intermediate ends 3 and 4. Insulator 5 surrounds two differently sized sets of three connectors 7 and 8 which, at one end, receive the cores of the cable and, at the other end, receive the connector pins that are located within the receptacle. Accordingly, electrical connection is selectively provided between the cores in the cable and the connector pins within the receptacle. One such receptacle is described and illustrated in Australian Patent Application No. 21600/95, the disclosure of which is incorporated herein by way of cross reference.

The end of the cable is received in an aperture 9 at end 4 of body 2 and subsequently secured by clamping means 10. The cores of the cable are separated in internal chamber 11 and inserted into respective cylindrical bores 12 in insulators 5 and secured to connectors 7 or 8, as appropriate.

Connectors 7 and 8 each include at one end a thimble 13 for receiving the free end of a respective cable core, as is known to those skilled in the art. The end of the core is soldered or otherwise connected to thimble 13. Each connector also includes, at its other end, a socket 14 for receiving a respective connector pin located within the receptacle. That is, the connector pins are received into engagement with respective sockets 14 when plug 1 is inserted into the receptacle. The respective pairs of thimble 13 and contact 14 are maintained in abutting electrical engagement by bolts 15.

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Insulator 5 also encases a phase barrier 16 which is a centrally located metal structure having three legs which extend radially outwardly between adjacent mains conductors. Barrier 16 is earthed via lead 17 and reduces the risk of phase to phase faults. In alternative embodiments barrier 16 includes a different number of legs.

5 Referring now to Figures 3 and 4, there is illustrated an electrical plug 21 according to the invention. The features of plug 21 which correspond with those of plug 1 are denoted by corresponding reference numerals.

10 Plug 21 includes six equally angularly spaced axially extending tubular insulators 22 which, best shown in Figure 4, have a central internal annular ridge 23 against which thimble 13 and socket 14 are collectively secured by the operation of bolt 15. It will be appreciated that thimble 13 and socket 14 provide the same function 15 as described above with respect to prior art plug 1.

Although in this embodiment insulators 22 are made from polyester, other insulating materials are used in other embodiments, for example, rubber, reinforced resin or ceramics. Moreover, in very high voltage applications each insulator 22 extends within a co-axially disposed additional insulator (not shown) to ensure greater 20 electrical isolation between the cores and connectors 7 and 8. Preferably, the internal diameter of the additional insulator is sufficiently greater than the external diameter of insulator 22 to provide an air gap therebetween.

25 Each insulator 22 includes at opposed ends annular shoulders 25 and 26 for abutting a complementary formation to retain the insulators in a fixed configuration with respect to body 2. At end 3 of body 2, that complementary formation is defined by the combination of a circular apertured plate 27 and an annular lip 28 which

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inwardly extends from end 3. Plate 27 includes a plurality of apertures which receive the ends of insulator 22, whereby plate 27 abuts against shoulder 25.

At the other end of insulators 22, the complementary formation is defined by a circular plate 29 which includes apertures corresponding to those in plate 27. These 5 apertures in plate 27 interact similarly with shoulders 26 of the insulators.

Both plates 27 and 29 are secured to body 2 by way of circumferentially spaced rivets 30. Moreover, these plates are structural members and provide additional strength to plug 21 and, accordingly, increase the useful lifetime of the product.

Moreover, plug 21 provides this additional strength while being lighter than the prior 10 art plug 1.

In this embodiment barrier 16 is also a structural member being engaged at opposed ends 31 and 32 by respective plates 27 and 29. The plates are forced toward each other and into clamping engagement with insulators 22 by the action of bolts 33 which are threadedly engaged within complimentary bores in barrier 16.

15 In other embodiments only the cores in the cable carrying supply voltages are within insulators 22, the pilot lines being of sufficiently low voltage that the intermediate air gap is adequate to prevent arcing therebetween.

20 In some embodiments, once the cable is installed within cavity 11, that cavity is filled with an expandable compound via a filling aperture (not shown). The compound stress relieves the cable termination and reduces the possibility of water ingress from outside the cable and plug, or through water entrapment within the cable (a function of the cable manufacturing process).

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Plate 27 is produced from a metal or hard plastics material and, accordingly, is resistant to damage from inadvertent contact with other objects. In the event plate 27 is damaged it can be easily replaced.

Reference is now made to an alternative electrical plug 41 according to the invention which is illustrated in Figures 5, 6 and 7. Where appropriate corresponding features have been denoted by corresponding reference numerals. More particularly, plug 41 includes a body 2 which extends between a first end 3 and a second end 4. These ends 3 and 4 are respectively configured for engagement with a complementary electrical plug (not shown) and receiving an electrical cable (not shown) having four cores. Plug 41 also includes four spaced apart connectors 42 for receiving at respective first ends 43 the cores and at respective second ends 44 a connector formation associated with the complementary plug to allow releasable electrical connection between the cores and the connector formations. Four insulating sheaths 45 extend about respective connectors 42 for electrically isolating connectors 42 from each other.

Connectors 42 are metallic and, as plug 41 is intended for low to medium voltage applications, sheaths 45 are plastics sleeves. In higher voltage applications, sheaths 45 are defined by a layer of ceramic material which is deposited on the outside of connectors 42. This arrangement effectively eliminates any air gap between the connectors 42 and the respective surrounding insulating sheaths 45 and thereby prevents corona discharge about those connectors.

Body 2 includes a generally cylindrical solid conductive nose cone 46 which extends along an axis 47 and which has four spaced apart parallel axially extending

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passages through which sheaths 45 extend. In this embodiment cone 46 is both metallic and earthed. Accordingly, cone 46 functions not only as a mechanical support for plug 41 but also as a phase barrier.

Cone 46 includes, at one end, shoulders 48 which extend across the periphery of 5 the adjacent passages to provide an abutment for one end of sheaths 45. Cone 46 also includes, at its other end, a removable end cap 49 which also extends across the periphery of the passages to provide an abutment for the other ends of sheaths 45. The combination of shoulders 48 and cap 49 captively retains sheaths 45 within cone 46.

In this embodiment, cap 49 is retained to cone 46 by a bolt 50 which is offset 10 from the passages. In other embodiments different attachment means are used.

Body 2 includes a hollow cylindrical housing 51 which extends along axis 47 between a first end 52 and a second end 53 which are respectively threaded internally and externally. End 52 also includes an abutment formation 55 for receiving a coupling nut 56. Moreover, cone 46 includes an abutment formation 57 and an 15 external thread 58. When thread 58 is engaged with end 52, as shown in Figure 6, nut 56 is captively retained between formations 55 and 57 for rotation about axis 47. Nut 56 includes an internal thread 59 for selectively engaging with a complementary thread of the electrical plug or receptacle.

End 53 is received within the complementary internally threaded end 65 of a 20 backnut 66. Sandwiched between end 53 and backnut 66 is a rubber grommet 67 and a washer 68. As will be appreciated by those skilled in the art, as the threaded engagement between backnut 66 and end 53 is increased, grommet 67 is compressed

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and therefore moves into a more intimate sealing and clamping engagement with the cable extending into housing 51.

Another electrical plug 71 according to the invention is illustrated in Figures 8 to 11 where, for convenience, corresponding features are denoted by corresponding reference numerals. In this embodiment plug 71 includes connectors 72 having four spaced apart axially extending pins 73 for engaging within complementary apertures of an adjacent plug, such as plug 41. Connectors 72 are housed within sheaths 45 and, as such, are insulated from each other. Moreover, the connector and sheath combinations are located within respective axial passages of a generally cylindrical conductive former 75. Former 75 is threaded to a tubular first and second body portions 76 and 77 and functions similarly to nose cone 49.

Plug 71 also includes a second tubular body portion 81 which extends between a first end 82 and an axially spaced apart second end 83. End 83 is, in use, captively engaged with a respective backnut 84, washer 85 and grommet 86, similarly to end 53 of housing 51.

Former 75 includes a shoulder 91 adjacent one end, and an end cap 92 adjacent the other end, for providing opposed abutments for sheaths 45. These abutments retain sheaths 45 and connectors 42 within the passages in former 75.

Preferably, cone 46 and former 75 are cast from copper and machined to include the respective passages.

A plug produced in accordance with the preferred embodiments of the invention offers a more durable and cost effective product which provides the necessary

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insulation between the cores at a weight significantly less than corresponding prior art plugs. By way of example, plug 21 is approximately 20% lighter than prior art plug 1.

Although the invention has been described with reference to a particular example it will be appreciated by those skilled in the art that it may be embodied in  
5 many other forms.

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## CLAIMS:-

1. An electrical plug including:
  - a body extending between a first end and a second end which are respectively configured for insertion into a corresponding receptacle and receiving an electrical cable having one or more cores; and
    - 5 at least one tubular insulator, the or each insulator having a connector for receiving at one end the respective ends of the one or more cores and at the other end a respective connector pin within the receptacle to allow releasable electrical connection between the cores and the connector pins.
- 10 2. A plug according to claim 1 further including:
  - a first and a second plate selectively located at or adjacent the first end of the body and intermediate the first and second ends of the body, both plates having a plurality of apertures which align with respective ones of said insulators; and
    - 15 retention means extending between said plates for captively retaining the insulators therebetween.
3. A plug according to claim 2 wherein the retention means includes a member extending through the cavity.
4. A plug according to claim 3 wherein the member is a phase barrier.
5. A plug according to claim 3 wherein the member is tensioned.
- 20 6. A plug according to claim 1 wherein the or each tubular insulator is cylindrical.
7. A plug according to claim 1 wherein the or each insulator has a square cross-section.

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8. A plug according to claim 1 including a plurality of insulators which are equally angularly spaced within the cavity.
9. A plug according to claim 1 wherein the or each insulator is surrounded by a respective additional tubular insulator.
- 5 10. A plug according to claim 9 wherein the or each insulator is separated from the additional insulator by an air gap.
11. A plug according to claim 1 wherein the connectors are disposed wholly within the respective tubular insulators.
12. An electrical plug including:
  - 10 a body extending between a first end and a second end which are respectively configured for engagement with a complementary electrical plug and receiving an electrical cable having one or more cores;  
one or more connectors for receiving at respective first ends the one or more cores and at respective second ends a connector formation associated with the complementary plug to allow relesable electrical connection between the cores and the connector formations; and  
one or more insulating sheaths extending about respective ones of the one or more connectors for electrically isolating the connectors from each other.
  - 15 13. A plug according to claim 12 wherein the connectors are metallic.
  - 20 14. A plug according to claim 12 or claim 13 wherein the sheaths are plastics sleeves.
  15. A plug according to claim 12 or claim 13 wherein the sheaths are defined by a layer of ceramic material which is deposited on the outside of the connector.

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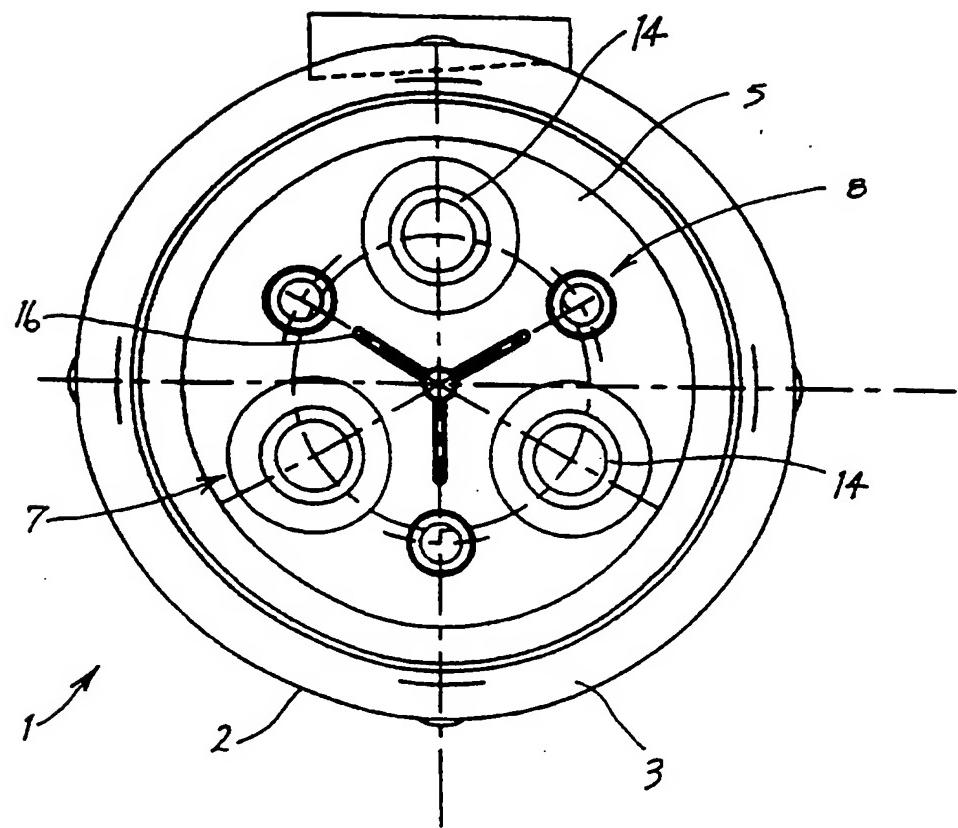
16. A plug according to any one of claims 12 to 15 wherein the body includes a solid conductive core.
17. A plug according to claim 16 wherein the core is generally cylindrical and includes a plurality of spaced apart parallel axially extending passages through which  
5 the respective insulating sheaths extend.
18. A plug according to claim 16 or claim 17 wherein the core is earthed.
19. A plug according to claim 16 or claim 17 wherein the core is metallic.
20. An electrical plug substantially as herein described with reference to any one of the embodiments illustrated in the accompanying drawings.

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FIG. 1

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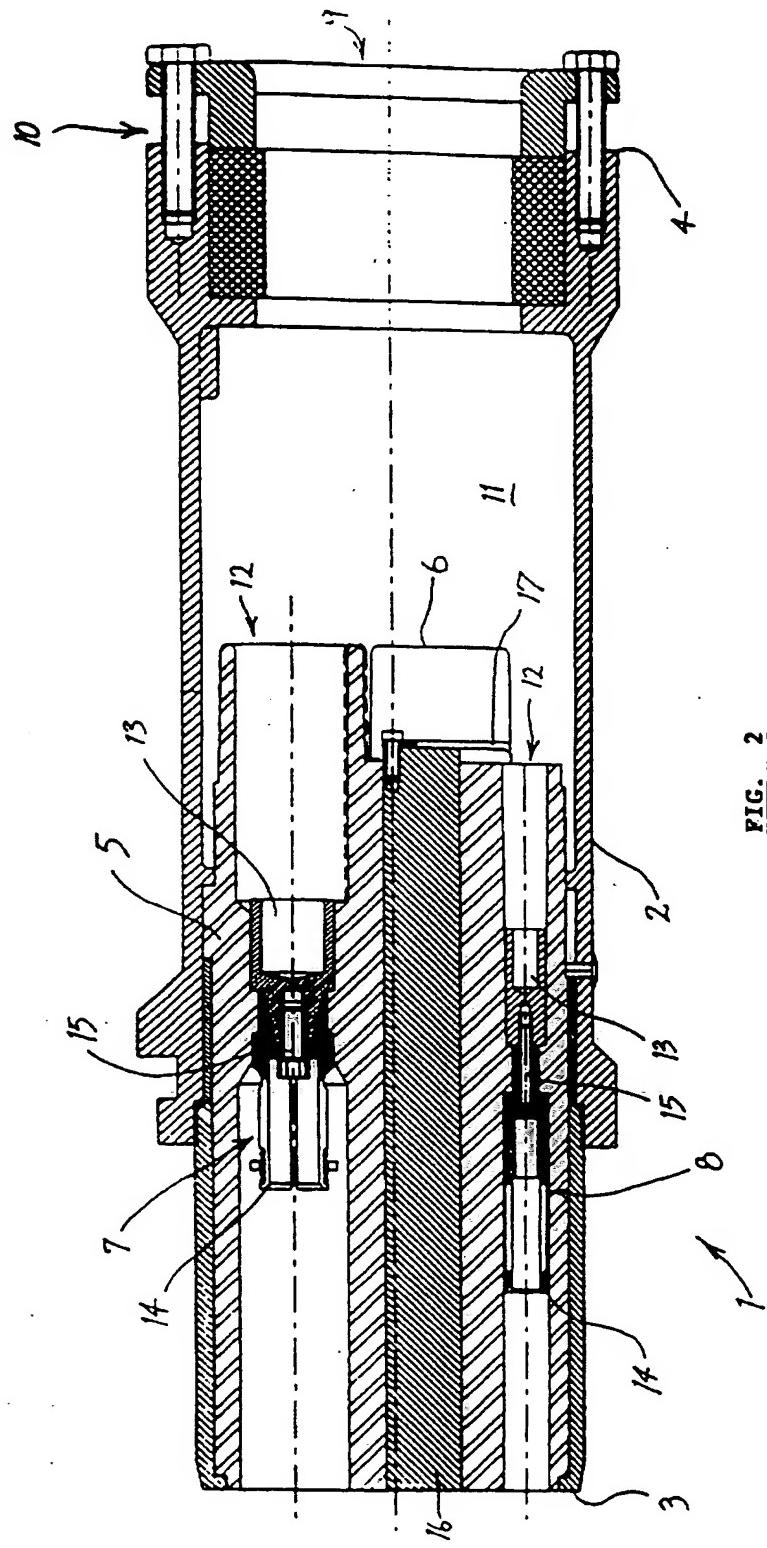


FIG. 2

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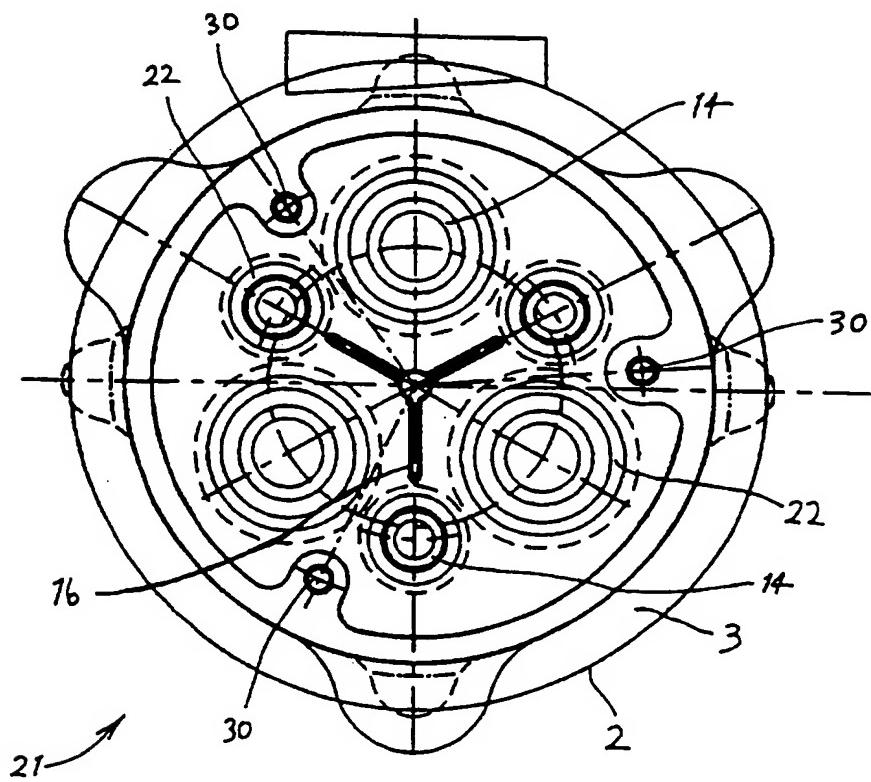


FIG. 3

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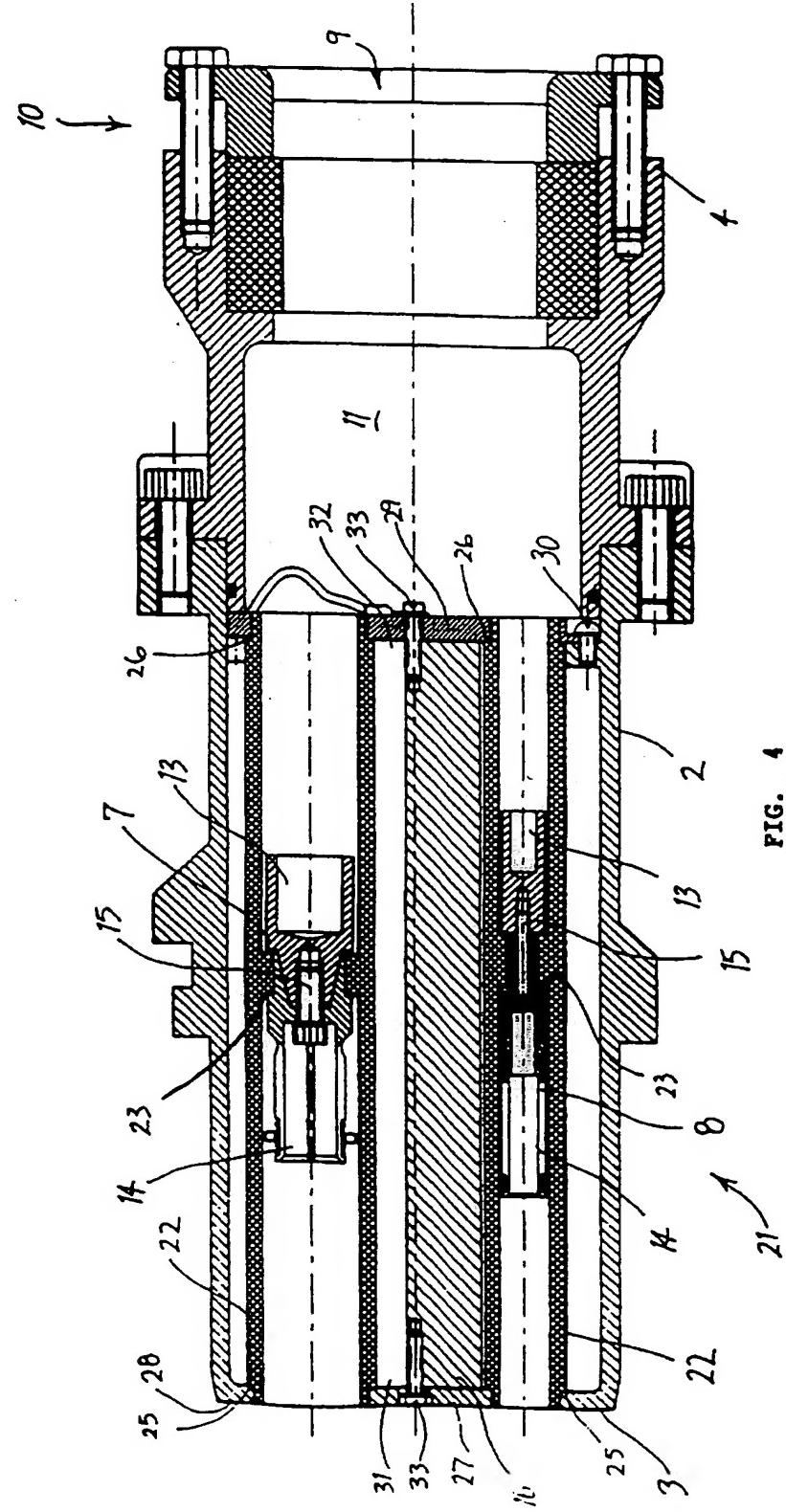


FIG. 4

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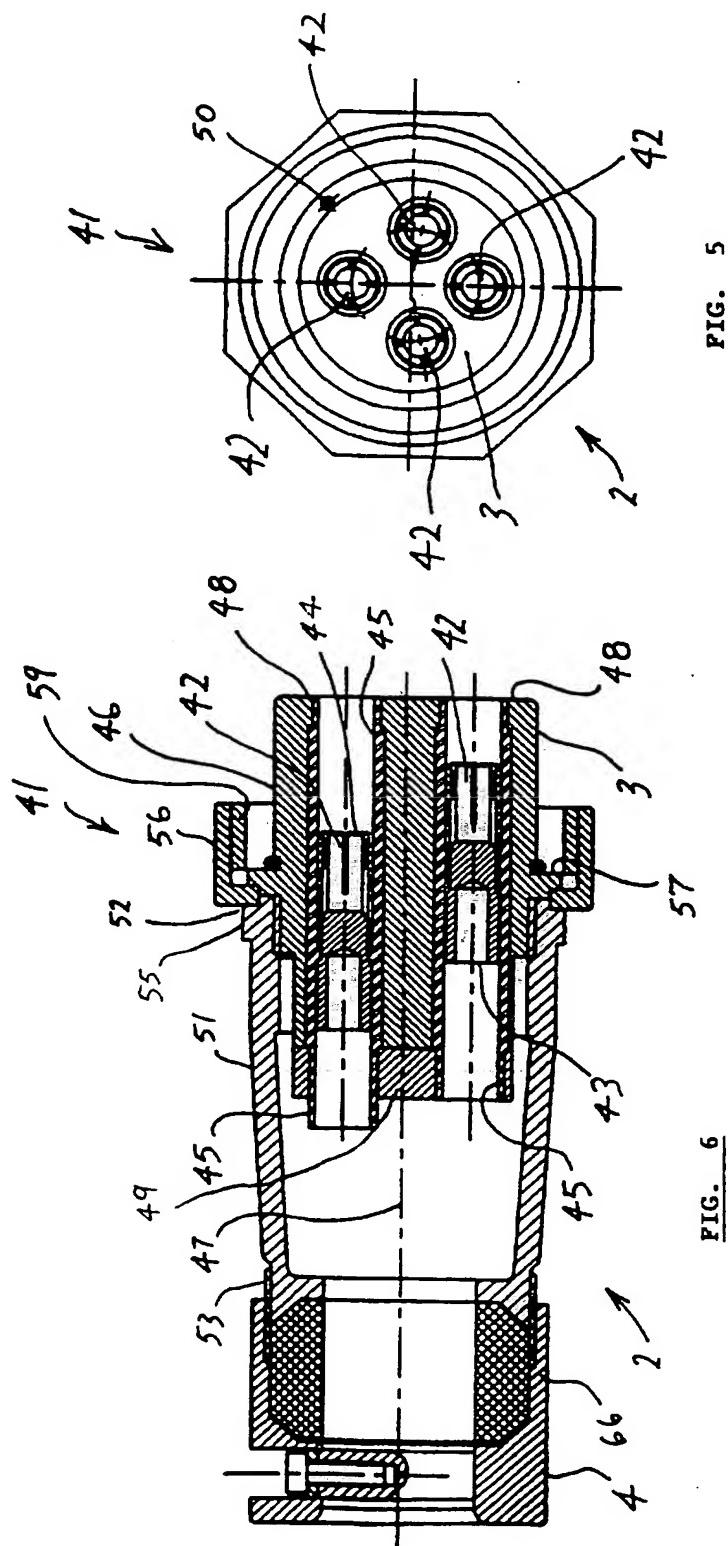


FIG. 5

FIG. 6

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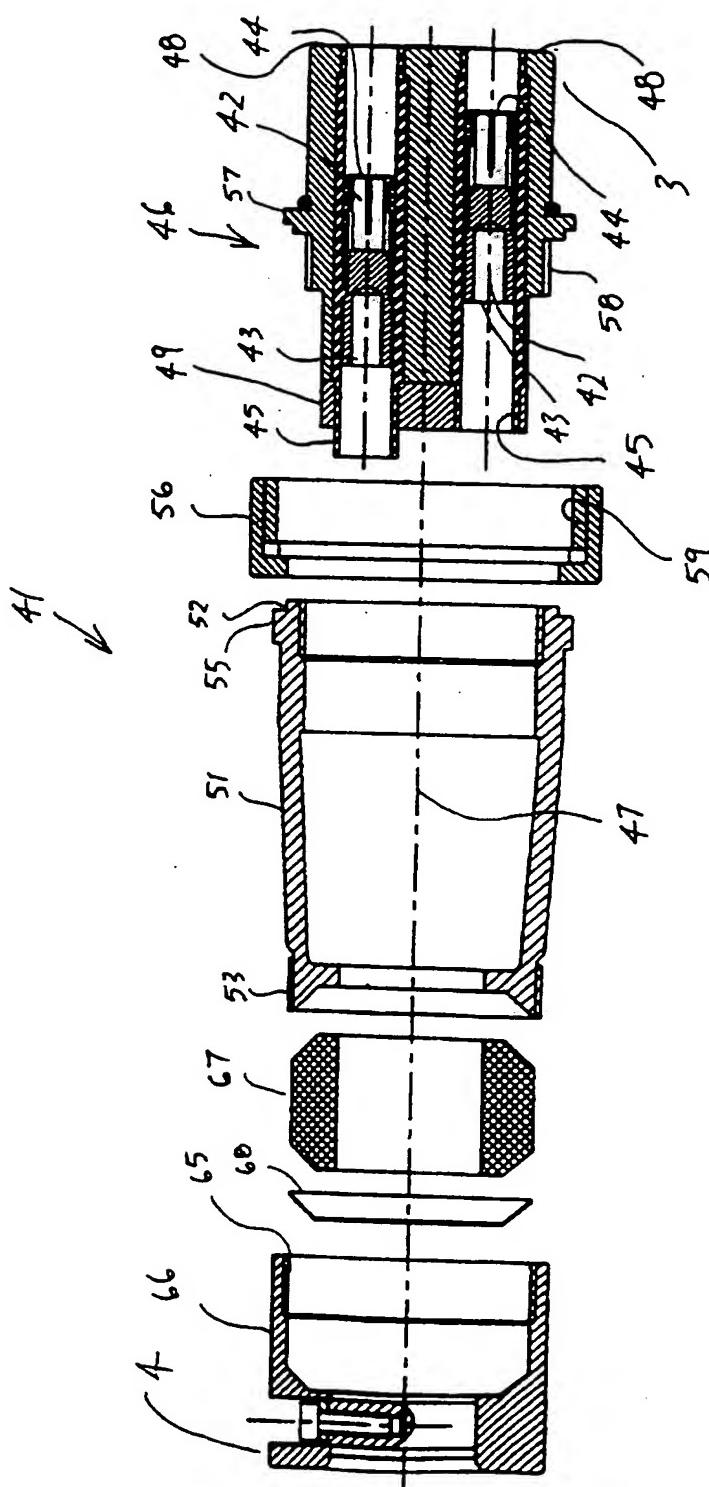


FIG. 7

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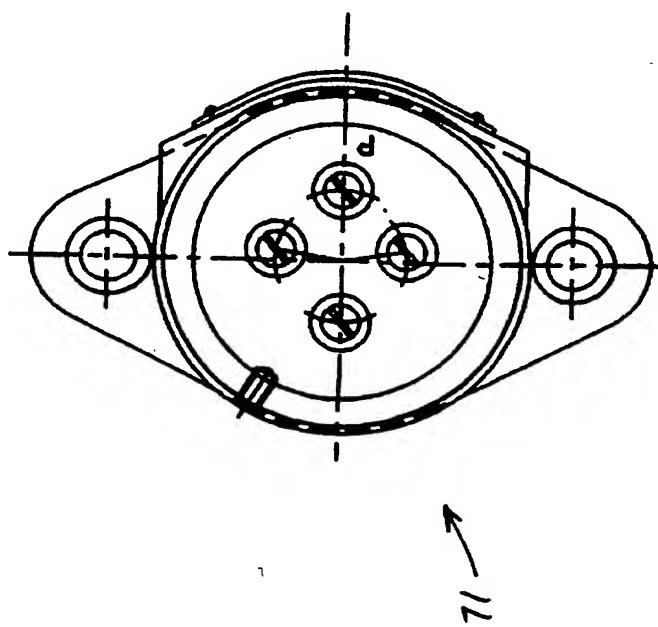


FIG. 8

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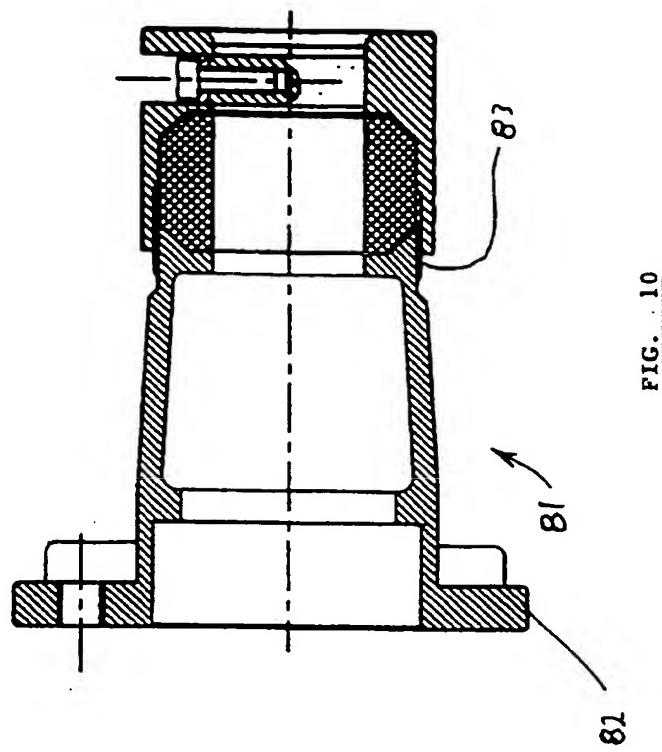


FIG. 10

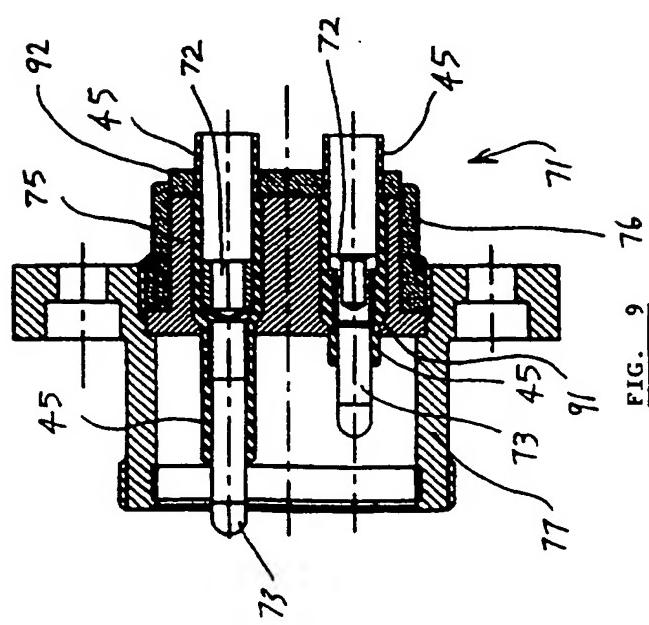


FIG. 9

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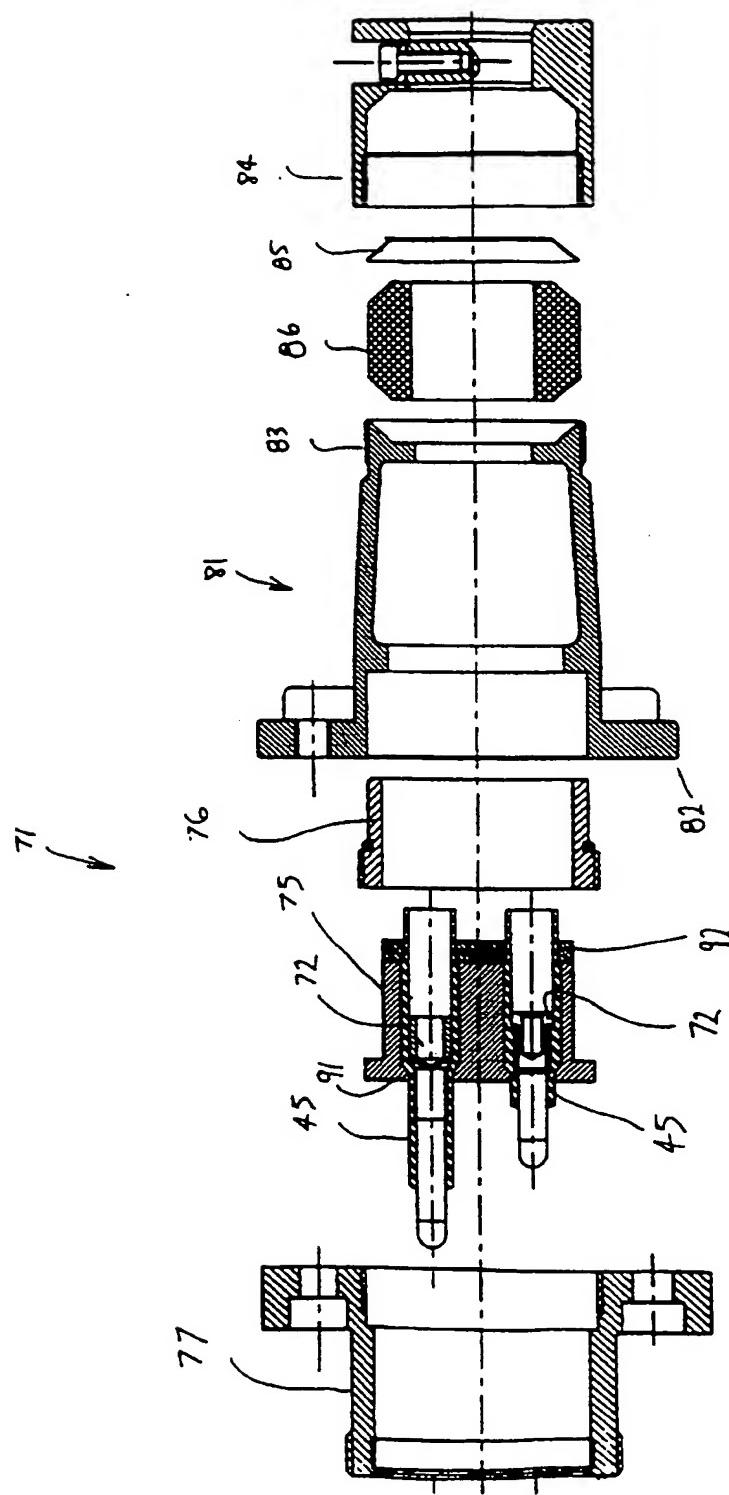


FIG. 11

## INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/AU 97/00651

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int Cl <sup>6</sup> : H01R 13/42, 13/533, 23/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC H01R 13/40, 13/42, 13/52, 13/53, 13/502, 13/512, 13/527, 13/533, H01R 23/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU : IPC as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category <sup>a</sup>	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0136156 A (BICC PUBLIC LIMITED COMPANY) 3 April 1985 Page 5 lines 23 to 24, Page 6 lines 1 to 4, Figures 1 and 2 Page 7 lines 9 and 27	1,6,8,11 to 14 16 to 19
Y		15
X	GB 2079547 A (BICC LIMITED) 20 January 1982 Whole document and page 2 in particular and figure 6	1,6,8,11 to 14 16 to 19
Y		15
X	AU 14735/92 A (PROOF ENGINEERING (PROPRIETARY) LIMITED) 15 October 1992 Figures 2 to 4, Page 10 lines 20 to 24, Page 12 lines 17 to 20	1,6,8,11 to 14,16 to 19
Y		15
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C		<input checked="" type="checkbox"/> See patent family annex
<ul style="list-style-type: none"> <li>o Special categories of cited documents:</li> <li>"A" document defining the general state of the art which is not considered to be of particular relevance</li> <li>"E" earlier document but published on or after the international filing date</li> <li>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>"O" document referring to an oral disclosure, use, exhibition or other means</li> <li>"P" document published prior to the international filing date but later than the priority date claimed</li> </ul> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>		
Date of the actual completion of the international search 20 October 1997	Date of mailing of the international search report 24 OCT 1997	
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	Authorized officer  J. W. THOMSON Telephone No.: (02) 6283 2214	

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International Application No.  
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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.